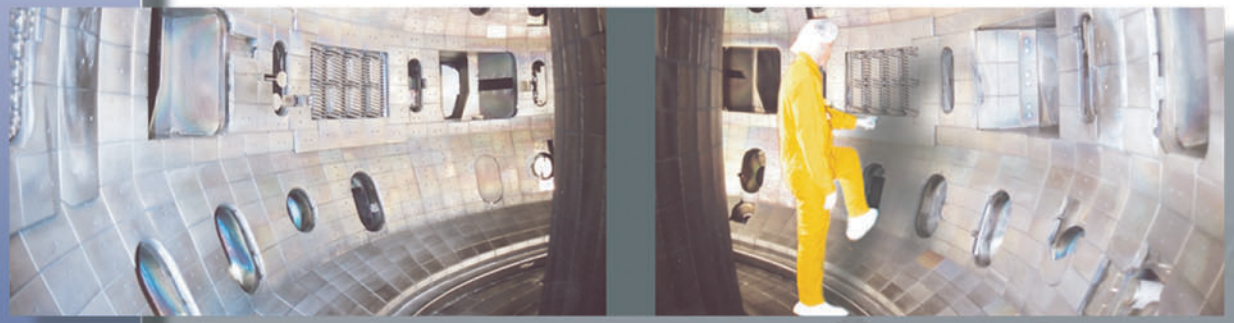
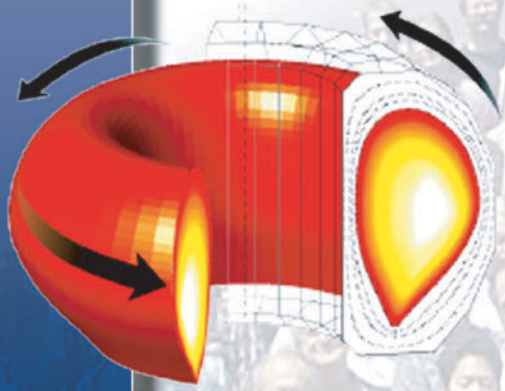
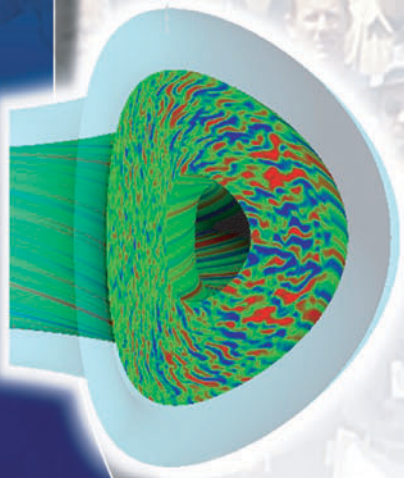






# DIII–D National Fusion Program

by
R.D. Stambaugh

Presented at
Office of Fusion Energy Science
FY07 Budget Planning Meeting
Washington, DC

March 15–16, 2005

032-05/RDS/rs

DIII–D
NATIONAL FUSION FACILITY
SAN DIEGO

GENERAL ATOMICS

# OUTLINE OF THE DIII–D PRESENTATIONS

| | | |
|---|---|---|
| ● Introduction | R.D Stambaugh (GA) | 10 minutes |
| ● DIII–D Research Program Plans | M.R. Wade (ORNL) | 30 minutes |
| ● University Research and DIII–D | G.A. Navratil (Columbia) | 15 minutes |
| ● DIII–D Program Budgets and Schedules | R.D. Stambaugh (GA) | 20 minutes |
| ● Discussion | | 10 minutes |

DIII–D NATIONAL FUSION FACILITY SAN DIEGO

# DIII–D SUPPORTS A HUGE INTERNATIONAL PROGRAM



- 90 institutions participate
- 425 active users
- 317 scientific authors
- Students and faculty from
  - 65 universities
  - 28 states

## Active Collaborations 2004

### US Labs

**ANL** (Argonne, IL)
**LANL** (Los Alamos, NM)
**LBNL** (Berkeley, CA)
**LLNL** (Livermore, CA)
**ORNL** (Oak Ridge, TN)
**PPPL** (Princeton, NJ)
**SNL** (Sandia, NM)

### Industries

**Calabasas Creek** (CA)
**CompX** (Del Mar, CA)
**CPI** (Palo Alto, CA)
**Digital Finetec** (Ventura, CA)
**DRS** (Dallas, TX)
**DTI** (Bedford, MA)
**FAR Tech** (San Diego, CA)
**IOS** (Torrance, CA)
**Lodestar** (Boulder, CO)
**SAIC** (La Jolla, CA)
**Spinner** (Germany)
**Tech-X** (Boulder, CO)
**Thermacore** (Lancaster, PA)
**Tomlab** (Willow Creek, CA)
**TSI Research** (Solana Beach, CA)

### US Universities

**Auburn** (Auburn, Alabama)
**Colorado School of Mines** (Golden, CO)
**Columbia** (New York, NY)
**Georgia Tech** (Atlanta, GA)
**Hampton** (Hampton, VA)
**Lehigh** (Bethlehem, PA)
**Maryland** (College Park, MD)
**Mesa College** (San Diego, CA)
**MIT** (Boston, MA)
**Palomar** (San Marcos, CA)
**New York U.** (New York, NY)
**SDSU** (San Diego, CA)
**Texas** (Austin, TX)
**UCB** (Berkeley, CA)
**UCI** (Irvine, CA)
**UCLA** (Los Angeles, CA)
**UCSD** (San Diego, CA)
**U. New Mexico** (Albuquerque, NM)
**U. Rochester** (NY)
**U. Utah** (Salt Lake City, UT)
**Washington** (Seattle, WA)
**Wisconsin** (Madison, WI)

### Russia

**Ioffe** (St. Petersburg)
**Keldysh** (Udmurtia, Moscow)
**Kurchatov** (Moscow)
**Moscow State** (Moscow)
**St. Petersburg State Poly** (St. Petersburg)
**Triniti** (Troitsk)
**Inst. of Applied Physics** (Nizhny Novgorod)

### European Community

**Cadarache** (St. Paul-lez, Durance, France)
**Chalmers U.** (Goteberg, Sweden)
**CFN-IST** (Lisbon, Portugal)
**CIEMAT** (Madrid, Spain)
**Consorzia RFX** (Padua, Italy)
**Culham** (Culham, Oxfordshire, England)
**EFDA-NET** (Garching, Germany)
**Frascati** (Frascati, Lazio, Italy)
**FOM** (Utrecht, The Netherlands)
**Helsinki U.** (Helsinki, Finland)
**IFP-CNdR** (Italy)
**IPP** (Garching, Greifswald, Germany)
**ITER** (Garching, Germany)
**JET-EFDA** (Oxfordshire, England)
**KFA** (Julich, Germany)
**Kharkov IPT,** (Ukraine)
**Lausanne** (Lausanne, Switzerland)
**IPP** (Greifswald, Germany)
**RFX** (Padova, Italy)
**U. Dusseldorf** (Germany)
**U. Naples** (Italy)
**U. Padova** (Italy)
**U. Strathclyde** (Glasgow, Scotland)

### Japan

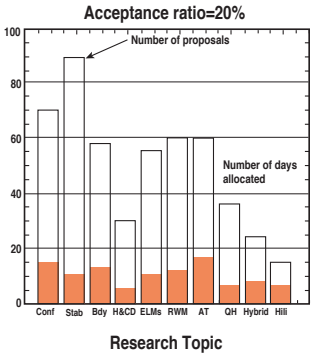
**JAERI** (Naka, Ibaraki-ken, Japan)
**JT-60U**
**JFT-2M**
**Tsukuba University** (Tsukuba, Japan)
**NIFS** (Toki, Gifu-ken, Japan)
**LHD**

### Other International

**Australia National U.** (Canberra, AU)
**ASIPP** (Hefei, China)
**Dong Hau U.** (Taiwan)
**KBSI** (Daegon, S. Korea)
**KAERI** (Daegon, S. Korea)
**Nat. Nucl. Ctr.** (Kurchatov City, Kazakhstan)
**Pohang U.** (S. Korea)
**Seoul Nat. U.** (S. Korea)
**SWIP** (Chengdu, China)
**U. Alberta** (Alberta, Canada)
**U. of Kiel** (Kiel, Germany)
**U. Toronto** (Toronto, Canada)

### STRONG INTERNATIONAL INTEREST IS SHOWN IN THE 451 RESEARCH PROPOSALS FOR 2004

| FOREIGN | DOMESTIC |
|---|---|
| Belgium 1 | Columbia 29 |
| France 4 | FarTech 2 |
| Germany 8 | GA 183 |
| JET 3 | Lehigh 2 |
| Portugal 3 | LLNL 23 |
| Spain 2 | NRL 1 |
| Italy 1 | MIT 3 |
| Switzerland 3 | ORNL 43 |
| Russia 3 | PPPL 66 |
| Japan 2 | SNL 9 |
| Australia 1 | UCI 2 |
| England 7 | UCLA 17 |
| Canada 4 | UCSD 18 |
| Total: 42 | U. Texas 4 |
| | U. Wisconsin 6 |
| | Unaffiliated 1 |
| | Total: 409 |




DIII-D NATIONAL FUSION FACILITY SAN DIEGO

032-05/RDS/rs

# DIII–D PROGRAM RECOGNITION IN FY04

- For their experimental research on toroidal Alfvén modes on DIII–D, Dr. E.J. Strait (GA) and Dr. W. Heidbrink (UCI), were recipients of the Award for Excellence in Plasma Physics Research in 2004. The citation reads "For the Theoretical Discovery and Experimental Identification of Toroidicity Induced Alfvén Eigenmodes." Dr. C.Z. Cheng (PPPL), Dr. K.L. Wong (PPPL), and Dr. L. Chen (UCI) were co-recipients of the award
- Dr. T.C. Luce (GA) became a Fellow of the American Physical Society "For definitive experimental investigation and analysis of key physics across a broad range of issues in magnetically confined plasmas, especially the physics of high power waves in plasmas, the establishment of nondimensional scaling properties, and the development of high performance discharge with potential for steady-sate"
- Dr. P.B. Snyder (GA) was chosen the recipient of the 2004 Rosenbluth Award for Fusion Theory for his pioneering contributions in the peeling-ballooning model of ELMs.
- Dr. V.S. Chan (GA) was elected vice-chair of the Division of Plasma Physics of the American Physical Society
- Dr. S.L. Allen (LLNL) was elected secretary-treasurer of the Division of Plasma Physics of the American Physical Society
- Dr. R.D. Stambaugh (GA) was chosen to give the Summary Presentation on Stability and Waves at the 20th IAEA Fusion Energy Conference
- Dr. G.A. Navratil (Columbia) gave a review presentation on ''Control of the External Kink Instability,'' at APS-DPP

DIII–D NATIONAL FUSION FACILITY SAN DIEGO

# SUMMARY OF HIGH VISIBILITY PRESENTATIONS OF THE DIII–D AND GA THEORY PROGRAMS

- 24 IAEA presentations and papers
- 9 APS-DPP invited presentations
- 1 APS-DPP review presentation
- 2 EPS invited presentations
- 2 HTPD invited presentations
- 2 PSI invited presentations
- 33 papers for the special issue of Fusion Science and Technology

DIII–D NATIONAL FUSION FACILITY SAN DIEGO

# FY05 STATUS

- Budget is $55,666K
- DIII–D is up and running
  - 14 run weeks planned by mid April
  - Recovered from MG Exciter Power Supply fault
  - Recovered from Line Reactor fault in 4160 Volt system
- Operated the new I-coil system for resistive wall mode and ELM suppression experiments
- Operated the ECH system in regular service for a variety of experiments, including suppression of neoclassical tearing modes and n=1 instabilities, long-term noninductive operation, plasma heating, particle-free H–mode production, and heating and current drive efficiency
- All three fast wave systems were brought back into operation (3 MW)
- GA has learned how to manufacture DIII–D ion sources
- All university turbulence diagnostics brought into operation
  - UCLA FIR
  - UCLA Microwave Scattering
  - Wisconsin BES
  - MIT PCI
  - UC-Irvine fast ion profile prototype

DIII–D NATIONAL FUSION FACILITY SAN DIEGO

# FY04–05 — 32 RUN WEEK CAMPAIGN FOR 6 THRUSTS AND TOPICAL SCIENCE AREAS

- Topical science areas provide broad scientific base
- Research thrusts are chosen to focus efforts on critical scientific issues and integrated scenario development

2004 Research Thrusts and Leaders

| | #1 Edge Pedestal | #4 Wall Stabilization | #6 High $\ell_i$ | #8 Advanced Scenario Development | #9 QH–Mode QDB | #10 Hybrid Scenarios |
|---|---|---|---|---|---|---|
| Topical Area Manager | M. Fenstermacher P. Snyder | M. Okabayashi H. Reimerdes | T. Luce J. Ferron | C. Greenfield A. Garofalo | P. West E. Doyle | M. Wade J. Jayakumar |
| Stability physics E. Strait | ✓ | ✓ | ✓ | ✔ | ✓ | ✓ |
| Confinement, transport physics K. Burrell | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Boundary physics S. Allen | ✓ | | | ✓ | ✓ | ✓ |
| Heating and current drive physics R. Prater | ✓ | | ✓ | ✔ | | ✓ |

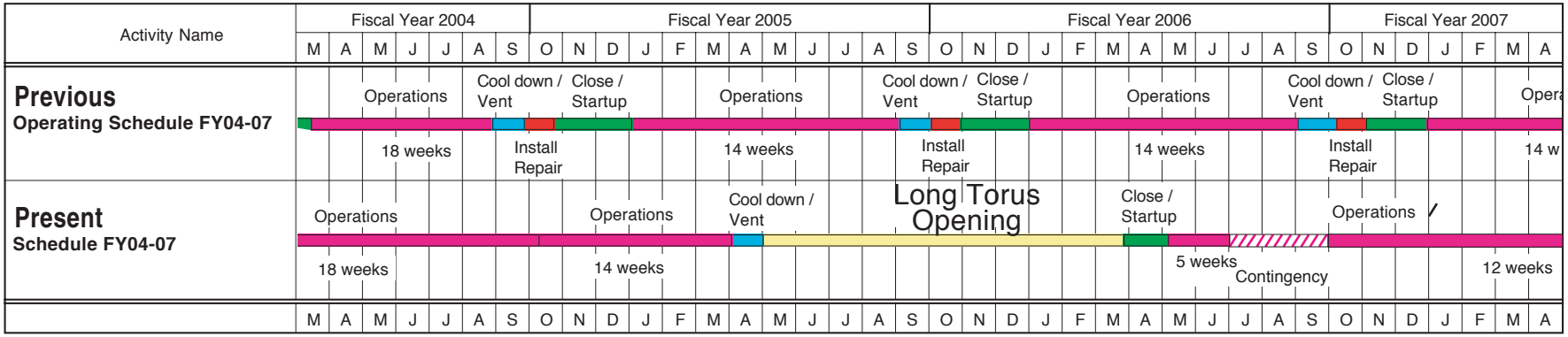
Table shows areas of strong overlap

DIII-D NATIONAL FUSION FACILITY SAN DIEGO

# WE ARE PROCEEDING WITH AN ALTERNATE OPERATING SCHEDULE

- Collects three vent periods (4 months each) into one 12 month torus opening
- Enables effective use of existing staff to take on some major projects
- Preserves run time capability
  - FY05 (14 weeks)
  - FY06 (5 run weeks, incremental request 12 weeks)
  - FY07 (12 run weeks, incremental request 25 weeks, new capabilities)

## DIII–D Facility Schedules (04–07)




- Enables:
  - ECH- 6 long pulse gyrotrons
  - Rotation of 210 degree beamline to counter and MSE diagnostic
  - Lower divertor modification
  - Cooling water tower replacement
  - MG refurbishment
  - TF belt bus cooling and freewheeling diodes for 10 s ops

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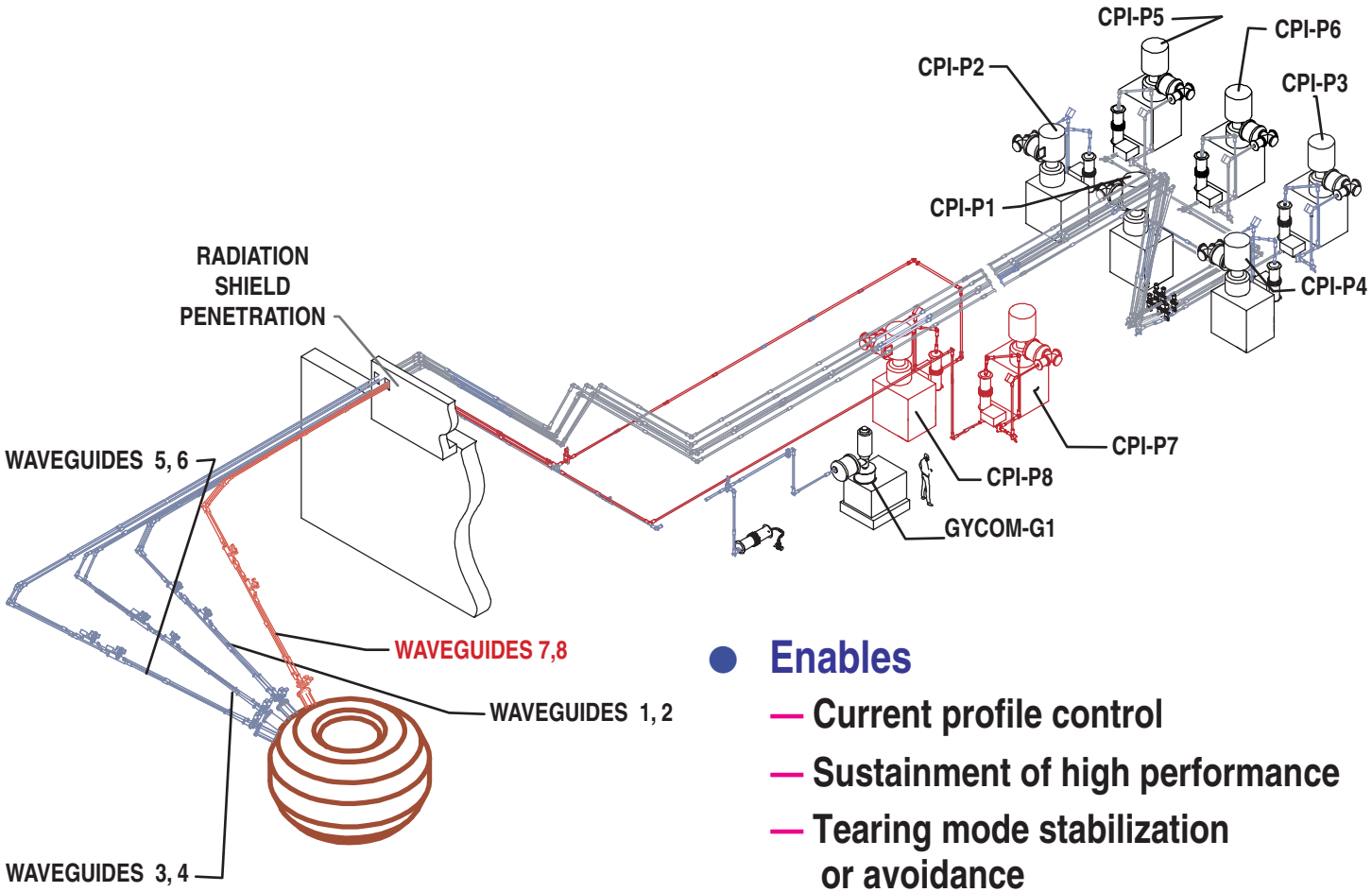
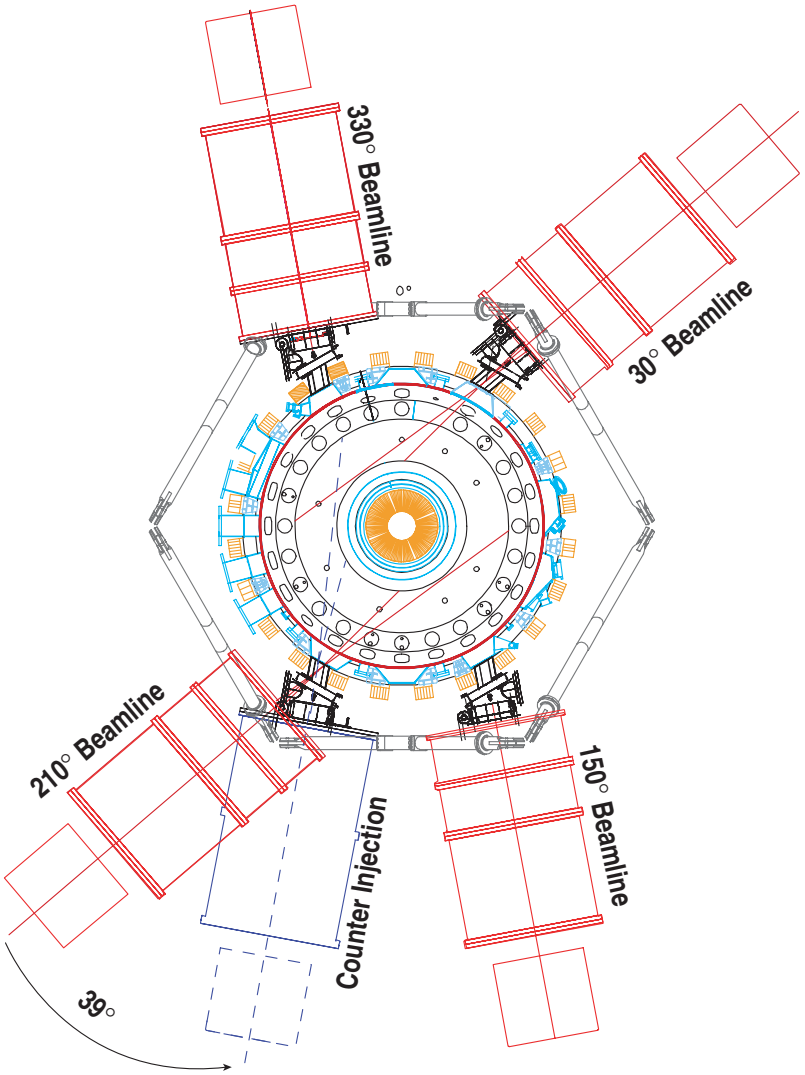
# EVENTUAL CONFIGURATION OF THE EC SYSTEM




- **Enables**
  - Current profile control
  - Sustainment of high performance
  - Tearing mode stabilization or avoidance
  - Transport barrier studies
  - Modulated transport and critical gradient studies
  - Electron heating

DIII-D NATIONAL FUSION FACILITY SAN DIEGO

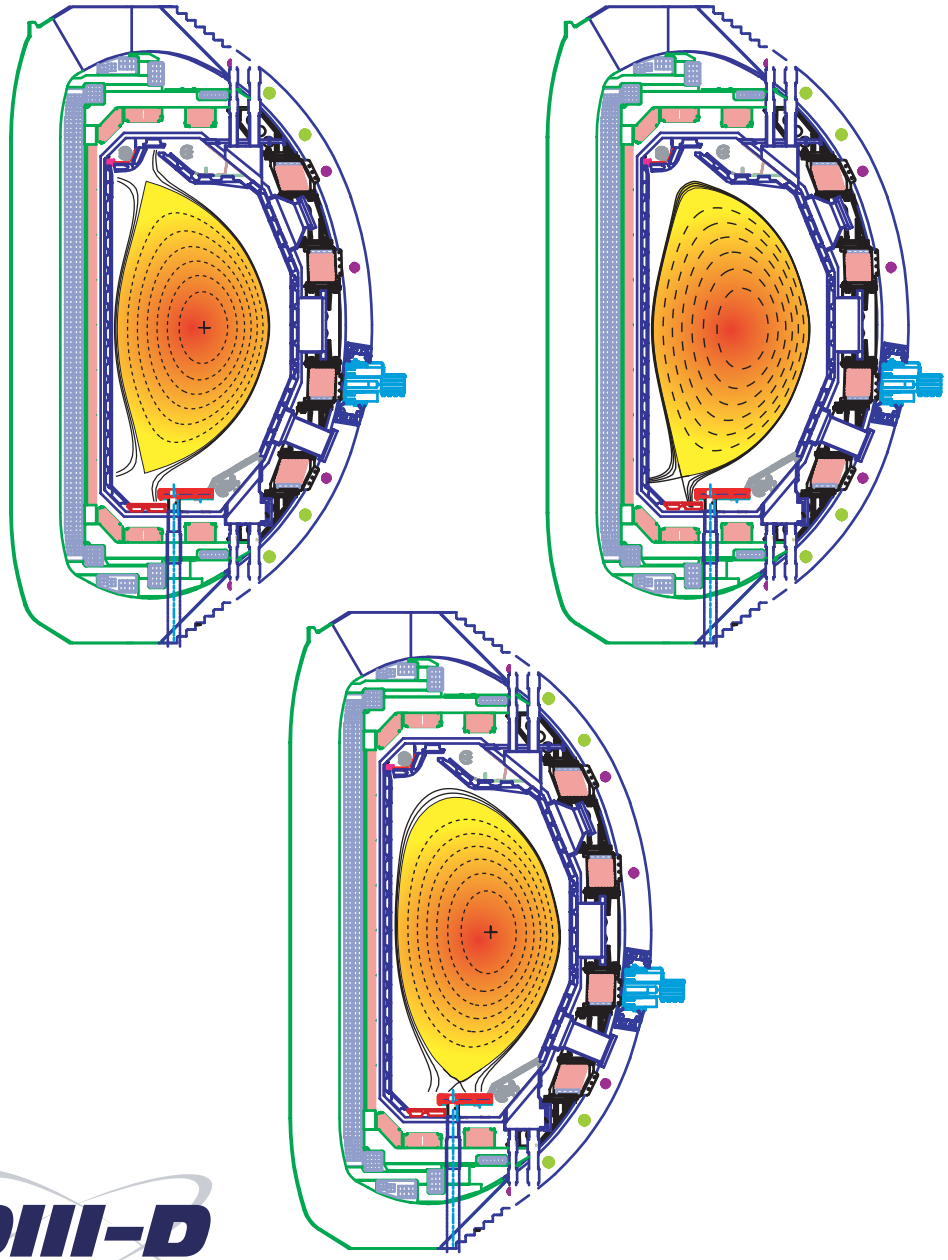
# ROTATION OF 210° BEAMLINE OPENS NEW REGIMES FOR PHYSICS STUDIES AND IMPROVED PLASMA MEASUREMENTS



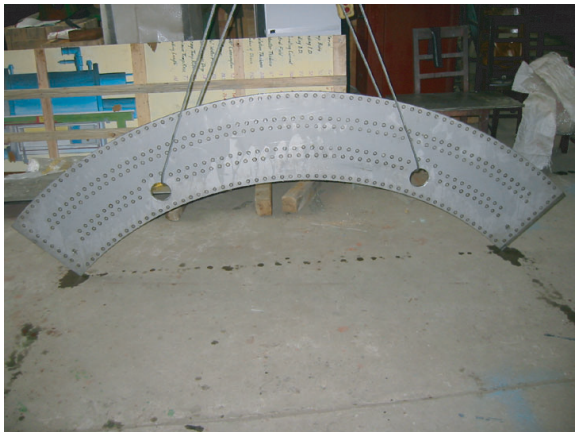

- **New physics**
  - QH–mode regime with central co-rotation
  - Understanding physics of rotation
  - RWM stability with low rotation
  - NTM stabilization with modulated rf
  - Transport barrier control (separate E×B and Shafranov shift effects)
  - Fast ion physics
  - Understanding the physics of NBCD
- **Diagnostics**
  - MSE measurement viewing counter beam allows separation of $E_r$ and J
  - Co and counter CER

DIII-D NATIONAL FUSION FACILITY SAN DIEGO

# NEW DIVERTOR MODIFICATION PROVIDES PHYSICS CAPABILITY AND MAINTAINS SHAPE FLEXIBILITY



- Density control at high performance
  - SN and DN AT and QH–mode
- Pedestal physics with range of $\nu^*$ ($n_e$)
- Mass transport physics (tritium uptake)
  - Microbalance diagnostics
  - Reduced carbon source from tile edges
- Optical access to the inner divertor leg
- Detachment control via pumping



Demonstration panel (ASIPP)



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# THE FY06 $4.3M GUIDANCE BUDGET REDUCTION WILL REQUIRE LARGE STAFF REDUCTIONS

| | FY05 | FY06 | FY07 |
|---|---|---|---|
| DIII–D National Budget | $55,666K | $51,374K | $57,101K |
| Run Weeks (Base Case) | 14 | 5 | 12 |
| FTE Total Program | 184.3 | 165.5 | 181.5 |

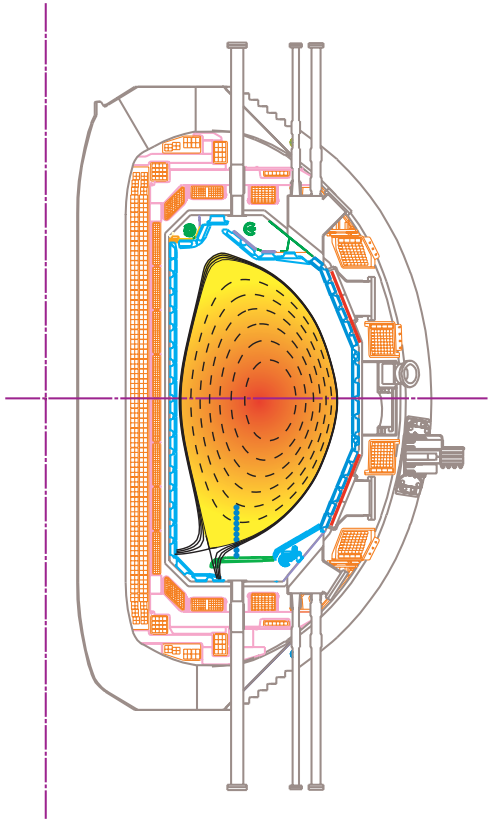
DIII–D NATIONAL FUSION FACILITY SAN DIEGO

# CONTINUED RESEARCH ON DIII–D UNTIL ITER OPERATES WILL SIGNIFICANTLY ADVANCE THE RESEARCH PROGRAM ON ITER

- Major DIII–D contributions to the science basis for ITER in confinement, stability, heating and current drive, pedestal, and divertor physics, and long-pulse scenario development

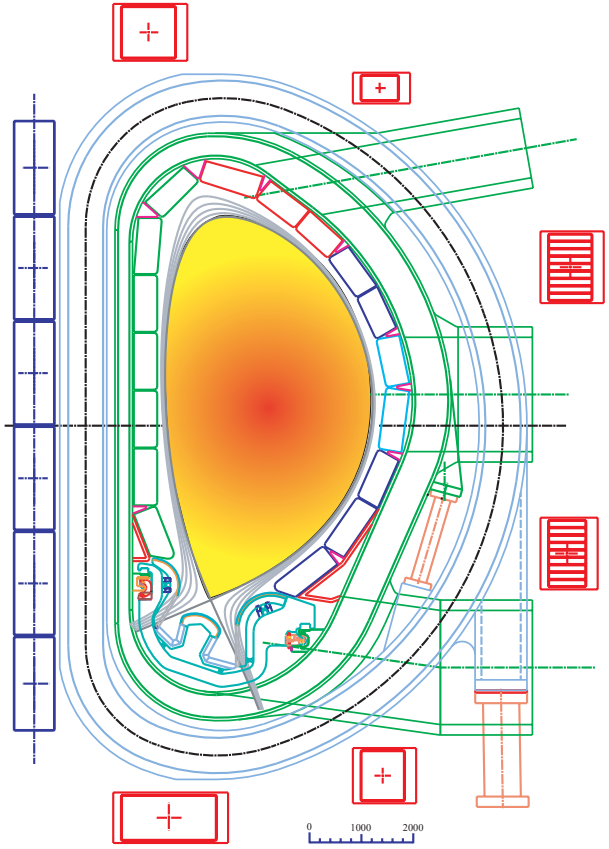
**DIII–D**

$\delta_{x\text{-}pt} = 0.63$



**ITER**

$\delta_{x\text{-}pt} = 0.58–0.68$




- DIII–D is ~1/4 scale ITER

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